NASA CONTRACTOR REPORT

NASA CR-914

THIN-FILM PERSONAL COMMUNICATIONS AND TELEMETRY SYSTEM (TFPCTS)

Prepared by
MELPAR, INC.
Falls Church, Va.
for Manned Spacecraft Center

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • NOVEMBER 1967

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THIN-FILM PERSONAL COMMUNICATIONS AND TELEMETRY SYSTEM (TFPCTS)

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ILLUSTRATIONS

1. INTRODUCTION

This final report for Phase B is submitted in compliance with Contract NAS 9-3924 between NASA-Houston and Melpar, Inc. The ultimate objective of the contract is to construct a thin-film personal communication and telemetry system. During Phase B the objective was to design and construct the circuit modules that will be used in Phase C to package the total system. Each module is designed to incorporate thin-film circuitry to the greatest extent possible.

Three results from Phase B seem to offer promise to the general electronics community. First is the development of a universal VHF thin-film circuit module which is used in all the VHF circuits, including such diverse functions as the modulator and power amplifier. This could be the introduction into a very inexpensive system fabrication method.

Second: The first IF module, the mask drawings of which are in the appendix of this report, and the second IF module are probably the most complex in total thin-film resistor and capacitor component count ever attempted. For example, the second IF module will be 1 x 3 inches in size and contain a frequency selective IF strip, its own AGC and an audio detector and amplifier. This will involve 42 thin-film resistors and 28 thin-film capacitors on each substrate. Of course, it is not the total number of resistors or capacitors that is of significance, but the fact that this large resistor-capacitor total will be attempted on an individual substrate. The attainment of any appreciable yields for this completely vacuum deposited thin-film circuit will be a breakthrough in the state-of-the-art.

Third: The thin-film voltage controlled oscillators fabricated for this contract have exceptional linearity with a wide frequency range over a voltage input span the equivalent of the B+ supply.

There were two major problem areas in Phase B. The module or substrate packaging techniques and the stability of the TFTs. As described in this report, a suitable packaging process which protects the substrates without affecting the electrical performance of the circuits has been evolved. Steps have been made in defining TFT stability problems and methods of stabilization are being tried. Most of the circuits have been designed using field effect transistors so that any breakthrough in achieving TFT stability will permit their use in the TFPCTS.

2. TECHNICAL DISCUSSION

The final TFPCTS electrical design is proposed and discussed in this section. Block diagrams for the transmitter and receiver are presented with each block representing an individual substrate or module. The modules vary in size from 1/2 x 1 inch to 1 x 3 inches.

There are two methods of operation in TFPCTS termed the Duplex and Simplex modes. The Duplex mode is simultaneous transmit and receive with seven continuous channels of telemetry. The Simplex mode contains the same transmitter and receiver as the duplex with these differences: there is no telemetry and the transmitter is keyed on by a voice operated switch. Each mode (duplex and simplex) will have individual diplexers and the determination of mode will be made by a coaxial switch. A functional TFPCTS system block diagram is shown in Figure 1.

2.1 Transmitter

The transmitter module diagram is presented in Figure 2. There are two transmitters in the TFPCTS; one in each mode. The simplex transmitter will be keyed by a voice operated switch as previously shown in Figure 1 and be fully modulated by the voice signal.

The modules are listed in Table 1. Since most of the VHF circuits are similar, a scheme was devised to fabricate a universal VHF substrate. The functional schematic is shown in Figure 3. This circuit permits, through trimming, the selection of the necessary components for fabricating all the various VHF circuits from the oscillator to the power amplifier.

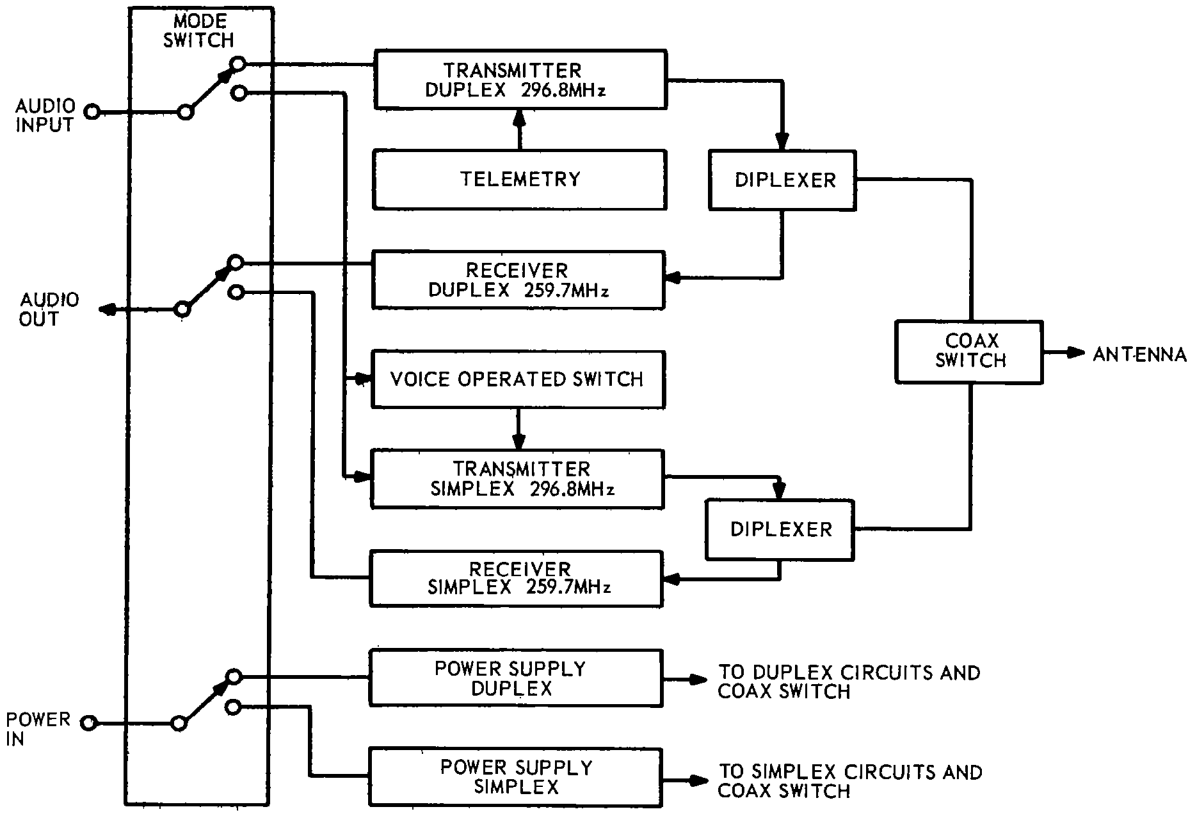


Figure 1. TFPCTS System Block Diagram

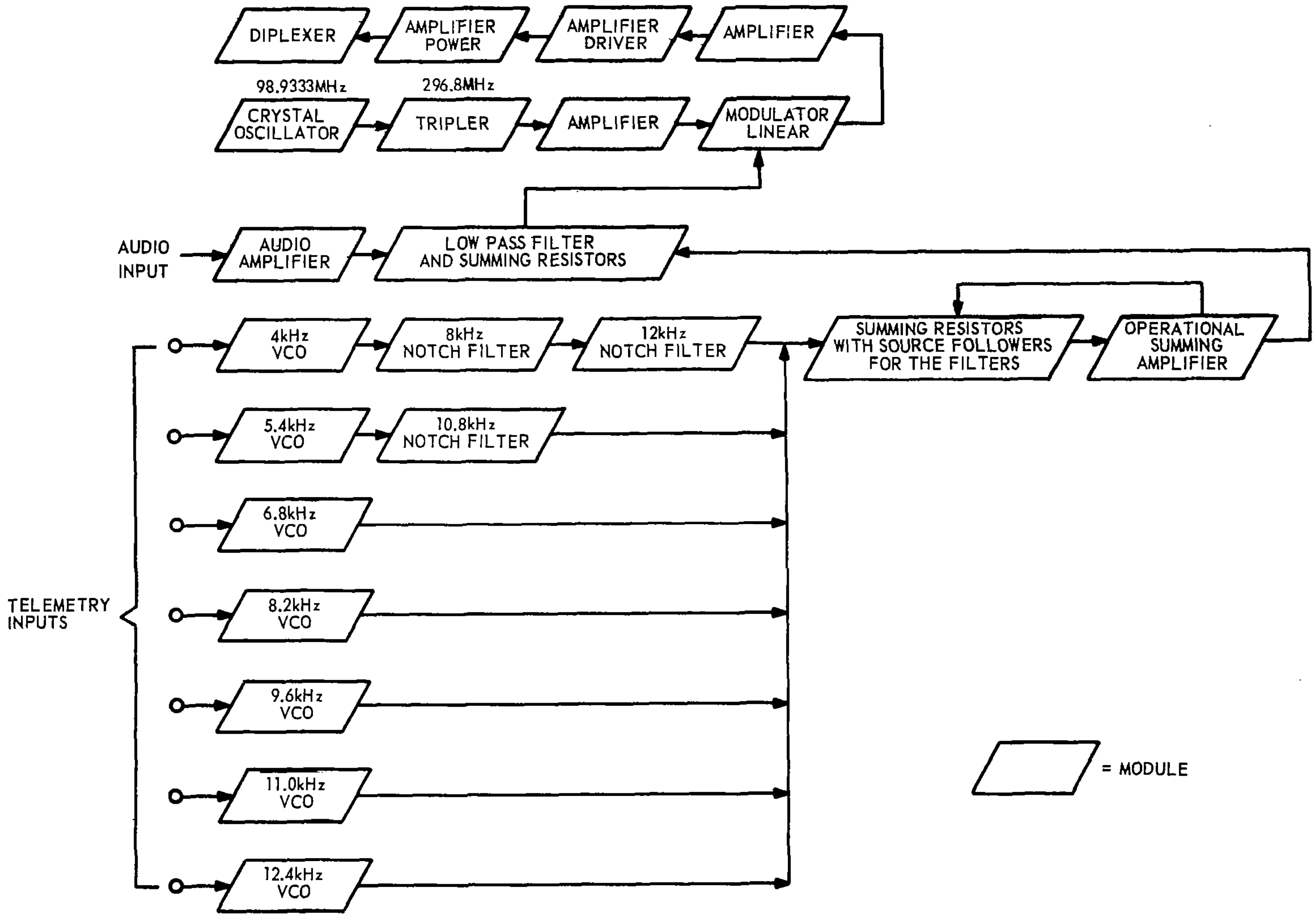


Figure 2. Transmitter Module Diagram

TABLE I

I. Transmitter modules

A. Audio frequency circuits

1. VCO (seven circuits)
2. Notch Filter (3 circuits)
3. Summing Resistors
4. Operational Summing Amplifier
5. Low Pass Filter
6. Audio Amplifier

B. VHF Circuits

1. Crystal Oscillator
2. Tripler
3. Amplifier
4. Modulator
5. Amplifier
6. Amplifier Driver
7. Amplifier Power
8. Diplexer

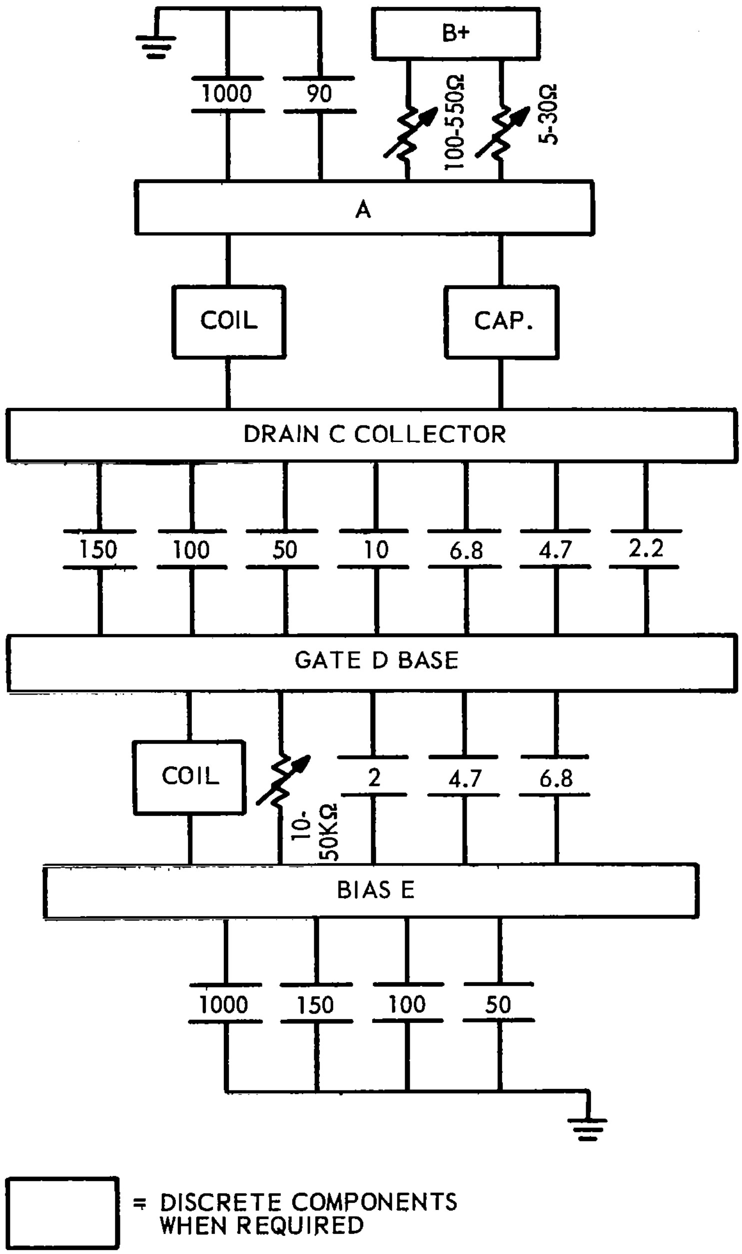


Figure 3. Thin-Film Universal VHF Module Schematic

2.2 Receiver

The receiver module diagram is shown in Figure 4. There are two receivers in the TFPCTS; one in each mode. There is no difference in the receiver operations.

The modules are listed in Table II. Although the frequency of the receivers differs from the transmitters, the resulting oscillator, tripler and amplifier circuits are the same modules as are used in the transmitter. The universal VHF modules are used for the remaining VHF circuits.

2.3 Packaging

The evolution of a satisfactory packaging technique for the modules has been tedious and elusive. For example, the use of vacuum wax over transistor chips has been found to weaken the connection of the one mil gold wire lead to the chip resulting in a poor, light sensitive electrical connection. Recently the elimination of the vacuum wax and using a first substrate coating of Humi Seal followed by RTV and a final coating of epoxy has resulted in physically strong modules without degrading the electrical performance.

2.4 Technical Summary

The various circuit schematics and discussions have been presented in the previous reports with the exception of the power supply which is determined by the final voltages required; and the voice operated switch which will be incorporated before the next quarterly report. The Diplexer was presented in the first quarterly report and has been fabricated in thin-film form. However, the precise trimming of the thin-film inductors and capacitors is so tedious that although thin-film diplexers have

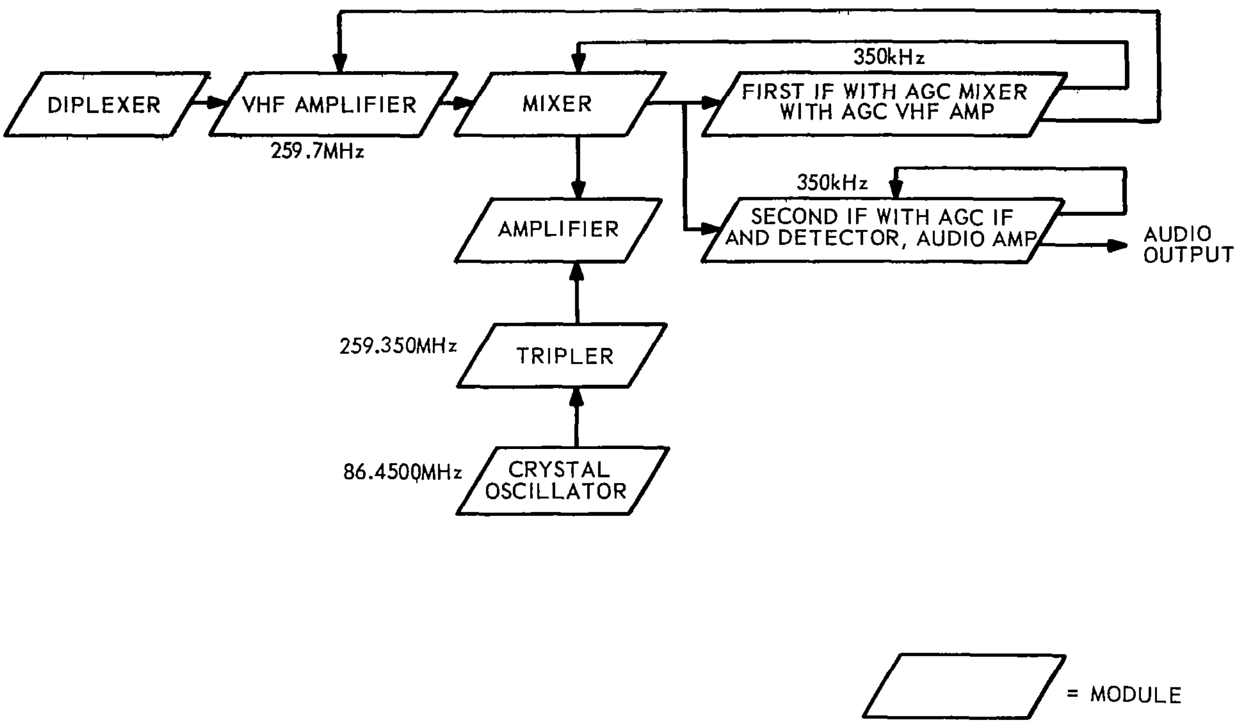


Figure 4. Receiver Module Diagram

Table II

I. Receiver Modules

A. IF, AGC and Audio Circuits

1. First IF with AGC
2. Second IF with Audio

B. VHF Circuits

1. Crystal Oscillator
2. Tripler
3. Amplifier
4. VHF Amplifier
5. Mixer
6. Diplexer

been proven operationally feasible, they are not practicable for this program. Therefore, a printed circuit version of the same diplexer using discrete trim capacitors will be used.

The breadboard version of the VHF transmitter is shown in Figure 5. The transmitter audio circuits and the first IF strip are shown in thin-film form in Figures 6 and 7.

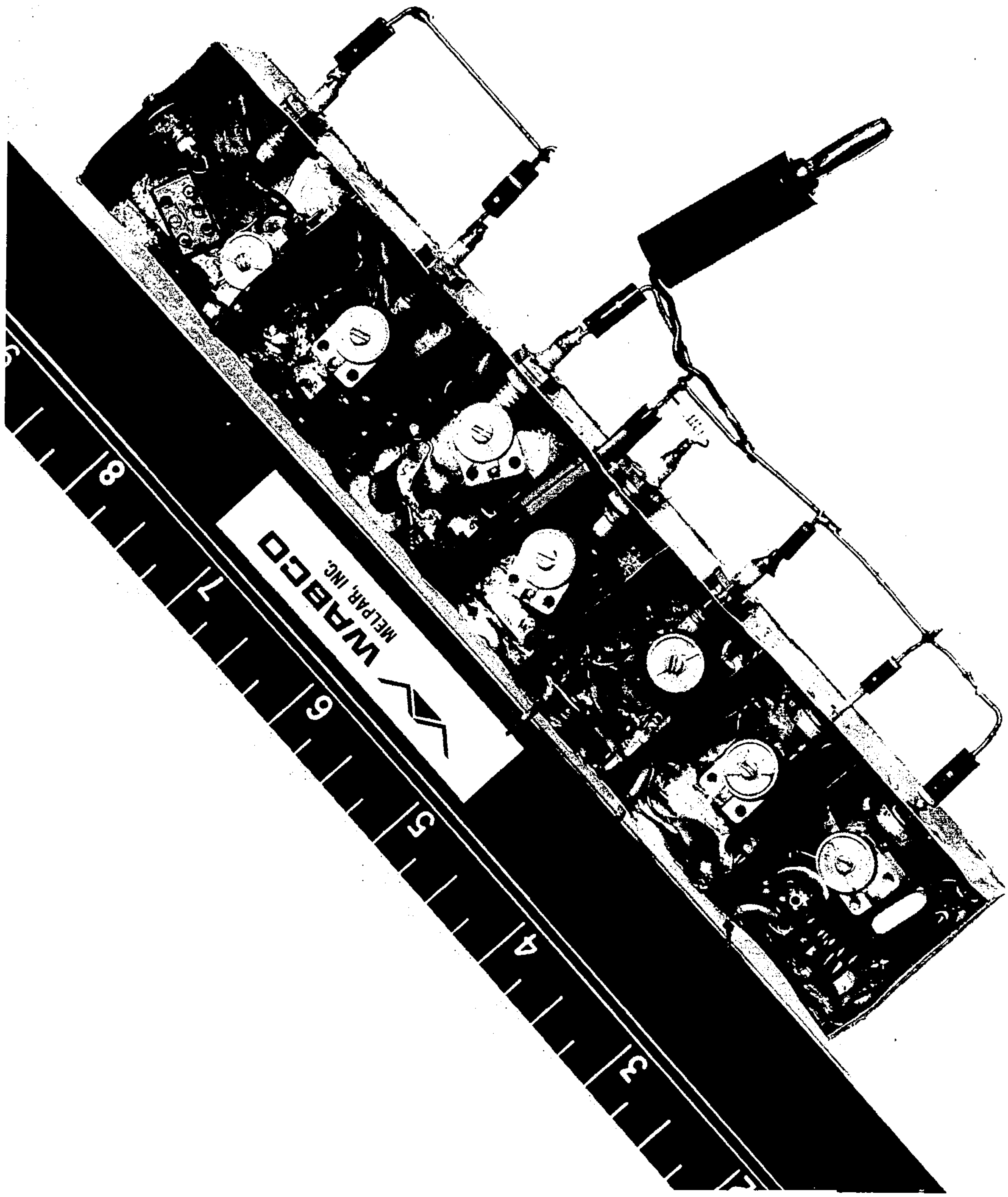
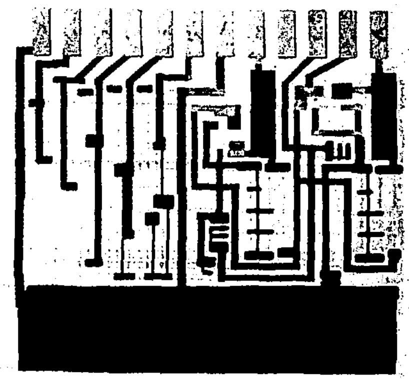
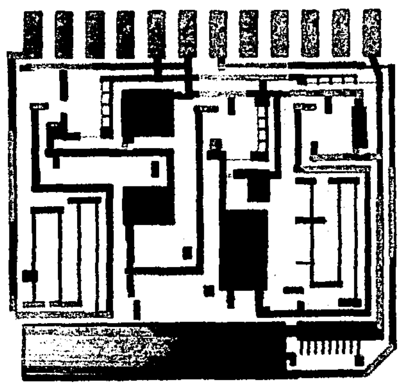


Figure 5. Transmitter, Discrete Version

(c)



(b)



(a)

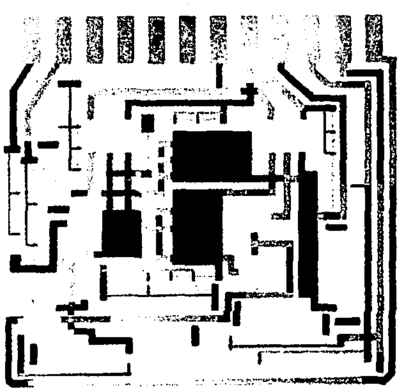


Figure 6. Thin-Film Audio Frequency Circuits
(a) Summing Resistors
(b) Operational Summing Amplifier
(c) Voltage Controlled Oscillator

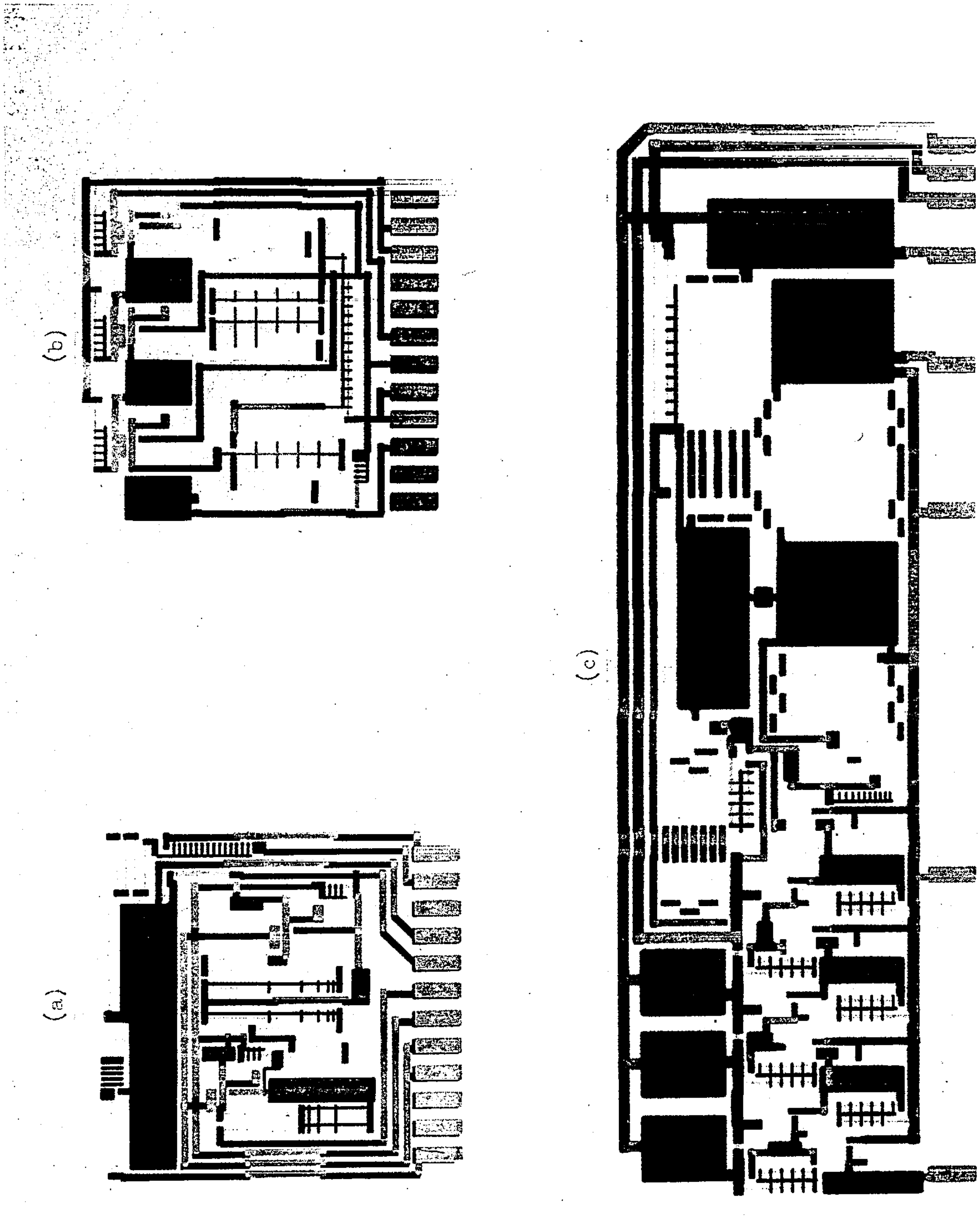


Figure 7. Thin-Film Audio Frequency and First IF Circuits
(a) Low Pass Filter
(b) Audio Amplifier
(c) First IF with AGC for Mixer and VHF Amplifier

3. PROJECT SCHEDULE

At this time all the TFPCTS modules listed in Tables I and II have been reduced to thin-film form and the masks have been made or are in the process of being made. The audio circuits are being packaged for delivery and the first IF is being deposited. The schedule is to complete all the deliverable modules for NASA by the end of the first quarter of Phase C.

3.1 PERT Chart

A PERT chart is presented in Figure 8. The chart shows the modules for delivery completed by the end of the first quarter of Phase C. The initial system packaging effort is being started as originally scheduled on March 24, the beginning of Phase C.

3.2 Estimate of Thin-Film Components

Since the last quarterly report the diplexer has been converted to discrete components involving approximately 4 coils and 4 capacitors. However, a thin-film voice operated switch has been added which will balance this change and maintain the overall TFPCTS system at approximately 75% thin-film components.

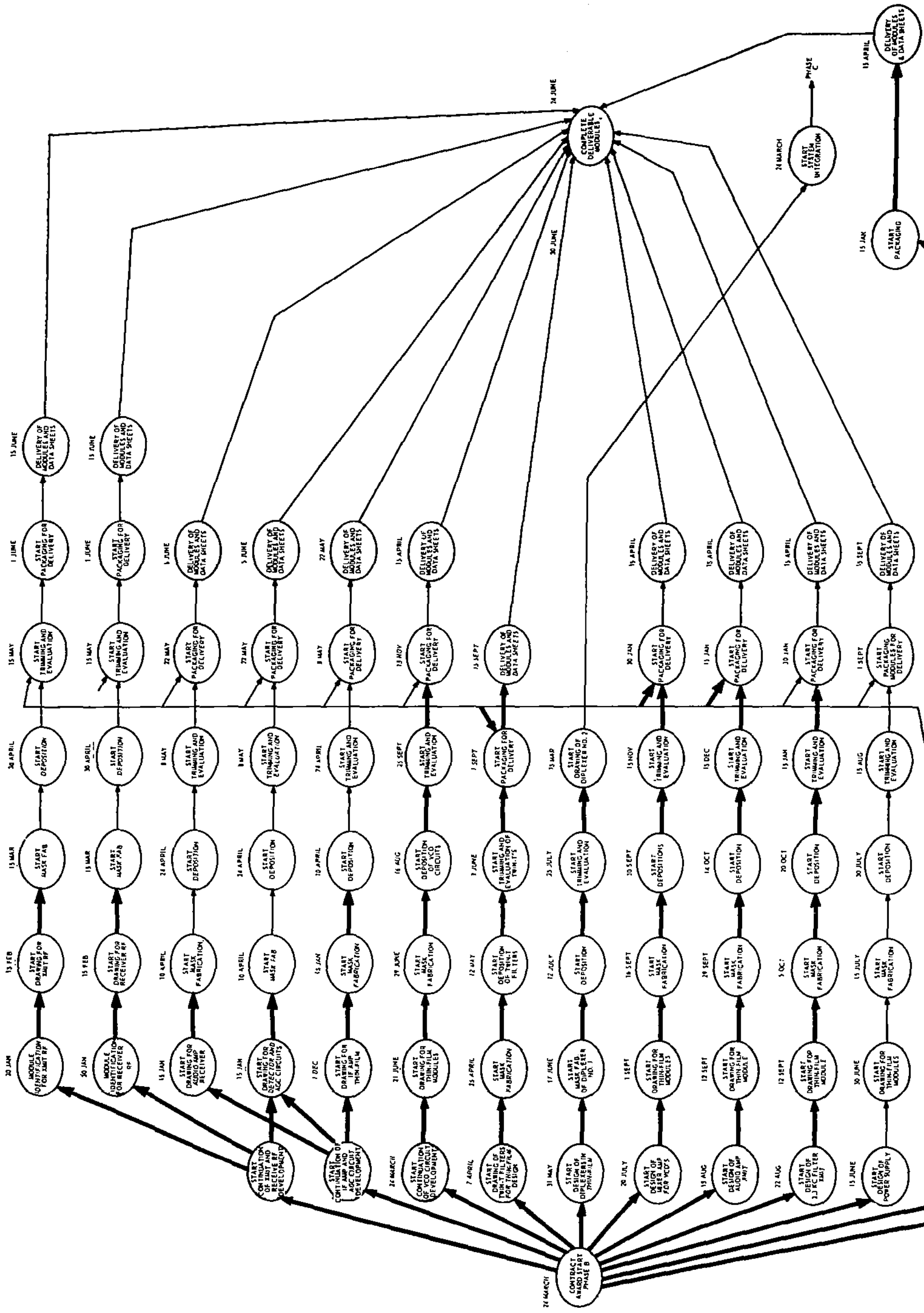


Figure 8. PERT Chart

4. SUMMARY AND NEXT PERIOD OBJECTIVES

Phase B has been scheduled for completion in five quarters. The fifth quarter overlaps the initiation of the work for Phase C. Therefore, the first quarterly report for Phase C should include the delivery of the necessary modules to officially complete Phase B; the first system packaging concepts; and the detailed PERT Schedule for Phase C.

5. PROGRAM PERSONNEL

The people listed here are the key personnel involved with this program.

5.1 Phase B

Project Leader	J. C. Mould
Senior Engineers	C. E. Gane
	F. J. Hemmer
	B. J. Weiner
Engineer	S. M. Muzidal

5.2 Phase C

Project Leader	J. C. Mould
Senior Engineers	F. J. Hemmer
	B. J. Weiner
Engineer	S. M. Muzidal

Mr. Muzidal will work 100% of his time on Phase C of this program.

APPENDIX A

Module Processing Information and Mask Drawings for the First IF Module

Thin Film Circuit Vacuum Process Chart for Melpar, Model I

RD-1070

"TFC Vacuum Processing Plant"

CHART NO. 5006-13

DATE:

ENGINEER:

PROJ. APPROVAL:

Circuit No. and Name: 5006-13 First IF Amplifier

Substrate Description: Corning Code 0211 Glass
$0.021 \pm .003 \times 1.000 \pm .010 \times 3.000 \pm .010$ inches

Substrate Cleaning Process No. 1

Mask Numbers:	Function
5006-13-1	A&D
-2	E
-3	B
-4	C
-5	F
-6	G
-7	H

	SPECIFICATIONS
1	High ohm/square resistors $\pm$ 21%
2	Low ohm/square resistors $\pm$ 36%
3	$R_c \geq 1000$ MΩ @ 1.5 Vdc
4	$V_b \geq 30$ Vdc continuous
5	DF $\leq$ 1%
6	
7	

Film Characteristics (in order of deposition)

Symbol	Circuit Function	Material	$R' = \frac{\rho}{L/W}$ Ω/sq.	$G' = \frac{L/W}{R}$ sq./Ω	$C' = \frac{C}{A}$ uuf/cm^2	Thickness Å	Other Characteristics
A	Terminals & Trim Bars	Cr	20 max.			500±20%	
B	Low ohm/square Resistor Film	Re	1k ± 21%			35*	* Calculated
C	High ohm/square Resistor Film	Re	10K ± 36%			20*	* Calculated
D	Terminals & Trim Bars	Al	3 max.			220	
E	Lower Capacitor Plates & Conductors	Al	.3 max.			2200	
F	Capacitors & Crossover Dielectric	70% SiO_2 30% B_2O_3			14,100 ± 10%	3000	
G	Upper Capacitor Plates & Conductors	Al	.3 max.			7200	
H	Protective Film	SiO				2000±20%	

TFC VACUUM PROCESS CHART
RD-1047

CIRCUIT NO.: 5006-13 First IF Amplifier (Sheet 2 of 3)

No.	Operations Chronological Order	Source Matl.	Mask Dash No.	Operation Duration	SUBSTRATE HEAT				SOURCE HEAT						MON. RES. AT CUT OFF
					MON. TEMP.	HEATER POWER			FILAMENT POWER			BEAM POWER			
				Min.	°C	AMPS	VOLTS	WATTS	AMPS	VOLTS	WATTS	AMPS mA	VOLTS kV	WATTS	OHMS kΩ
1	Dep. Term. & Trim. Bars	Cr	1	2 ± 0.2	200 ± 10		2.5		a	b	c	400	1	400 ± 5	
2	Dep. Initial Res. Layer	Re	3	10	465 ± 5		10		a	b	c	160	4.3	700 ± 5	13.3 ± 5%
3	Anneal Above	Re	3	10	465 ± 5		10		0	0	0	0	0	0	
4	Dep.& Anneal Final Res.Lay.	Re	3	10	465 ± 5		10		a	b	c	100	5	500 max.	12.5 ref.
5	Dep. Initial Res. Layer	Re	4	2	460 ± 5		9		a	b	c	160	4.3	700 ± 5	10.5 ± 1%
6	Anneal Above	Re	4	10	460 ± 5		9		0	0	0	0	0	0	330 ± 5%
7	Dep. & Anneal Final Res.Lay.	Re	4	10	460 ± 5		9		a	b	c	100	5	500 max.	200 ref.
8	Dep. Term. & Trim Bars	Al	1	1 ± 0.1	200 ± 5		2.5		a	b	c	400	.8	320 ± 5	165 ± 1%
9	Deposit Cond. #1	Al	2	10 ± 1	200 ± 5		2.5		a	b	c	400	.8	320 ± 5	
10	Dep. Cap. Dielectric	B_2O_3 SiO	5	30 ± 1	150 ± 5		2		a	b	c	320	.63	200 ± 5	

(a) 17.5 ± .5 (b) 10.7 ± 1 (c) 187

TFC VACUUM PROCESS CHART
RD-1047

CIRCUIT NO.: 5006-13 First IF Amplifier (Sheet 3 of 3)

No.	Operations Chronological Order	Source Matl.	Mask Dash No.	Operation Duration Min.	SUBSTRATE HEAT MON. TEMP. °C	HEATER POWER AMPS	HEATER POWER VOLTS	HEATER POWER WATTS	SOURCE HEAT FILAMENT POWER AMPS	FILAMENT POWER VOLTS	FILAMENT POWER WATTS	BEAM POWER AMPS mA	BEAM POWER VOLTS kV	BEAM POWER WATTS	MON. RES. AT CUT OFF OHMS kΩ
11	Anneal Above	-	5	15 ± 1	300 ± 5		6		0	0	0	0	0	0	
12	Deposit Cond. #2	Al	6	10 ± 1	200 ± 5		3.5		a	b	c	400	.8	320 ± 5	
13	Deposit Prot. Film	SiO	7	15 ± 1	200 ± 5		3.5		a	b	c	200	.5	100 ± 5	

(a) 17.5 ± .5 (b) 10.7 ± 1 (c) 187

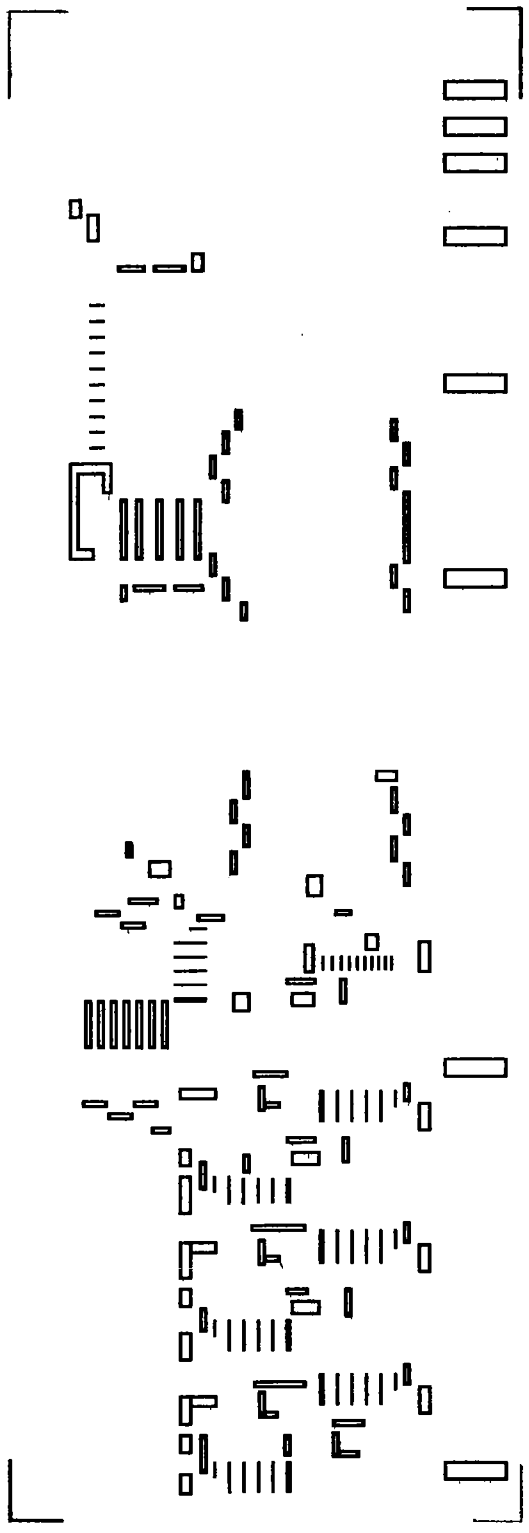


Figure A-1. Chromium Conductor Mask

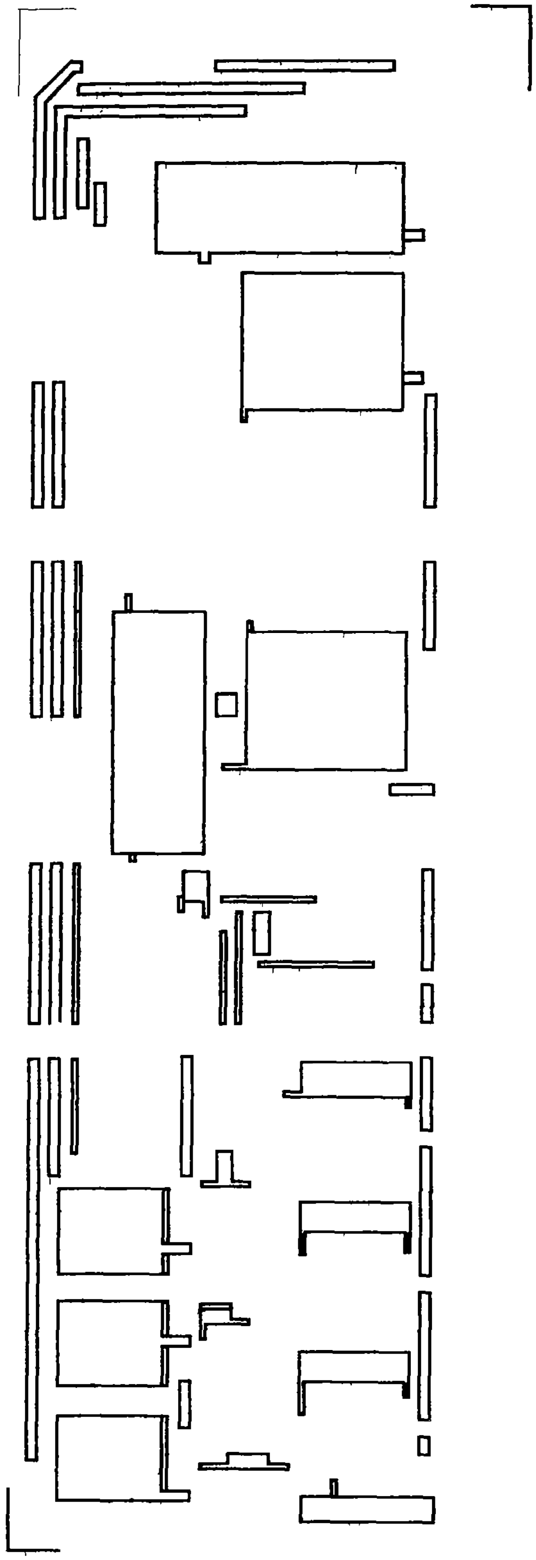


Figure A-2. First Conductor Mask

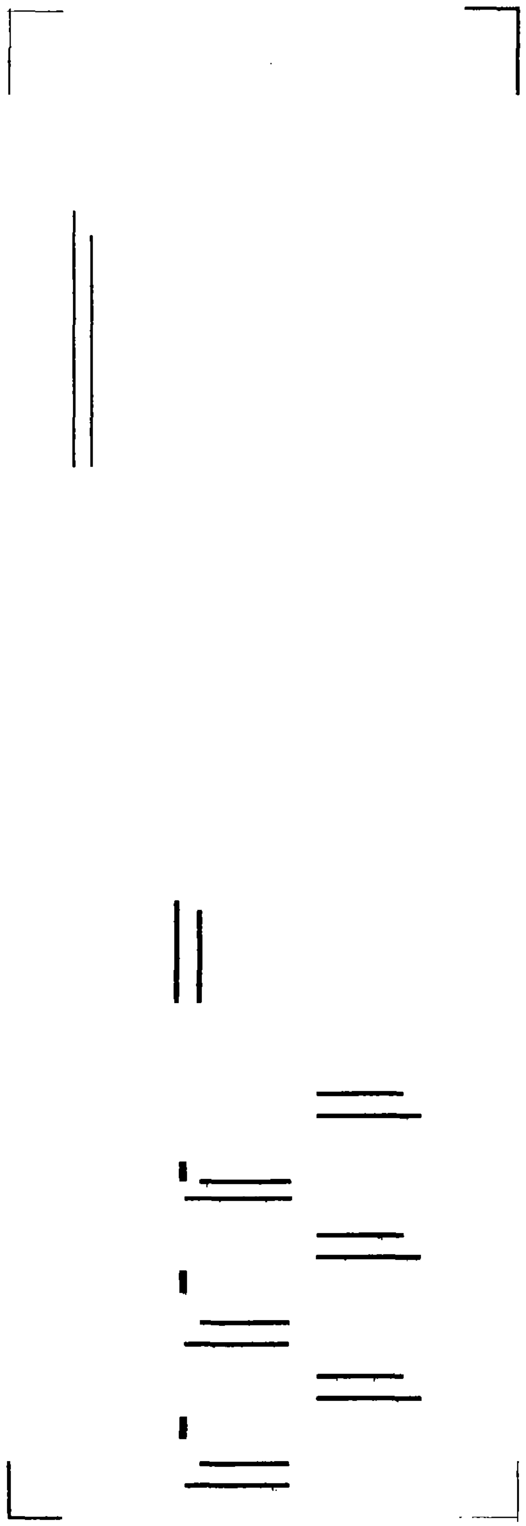


Figure A-3. Low Value Resistor Mask

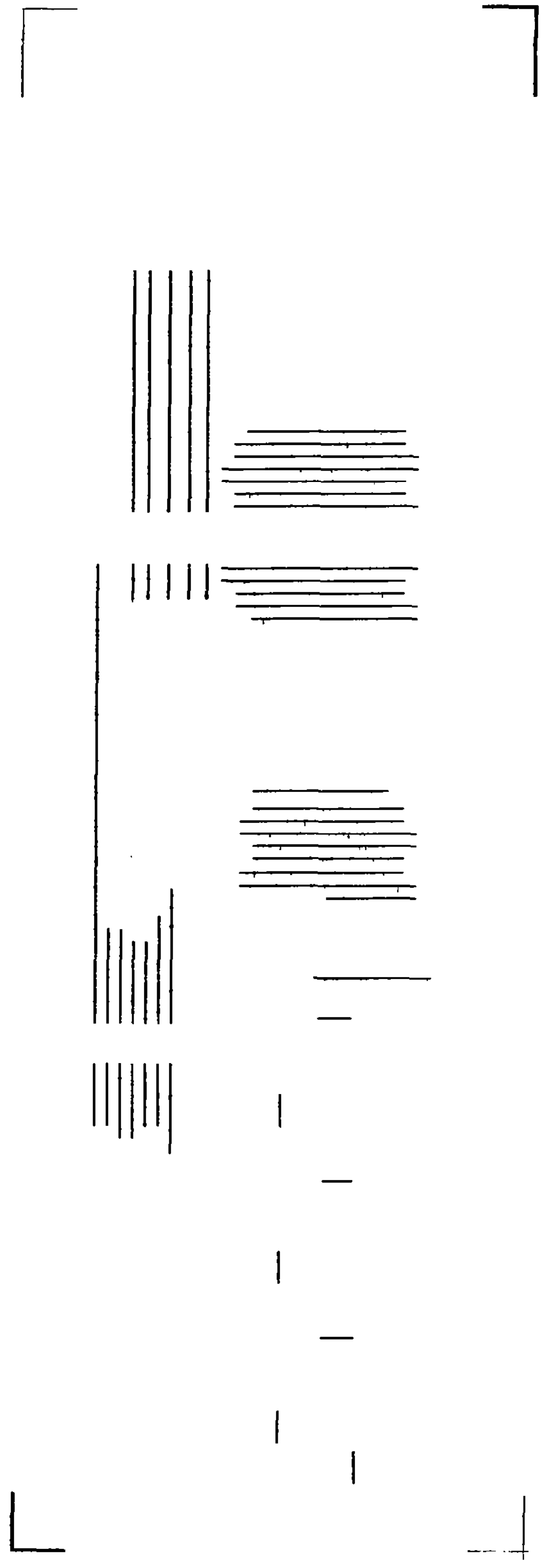


Figure A-4. High Value Resistor Mask

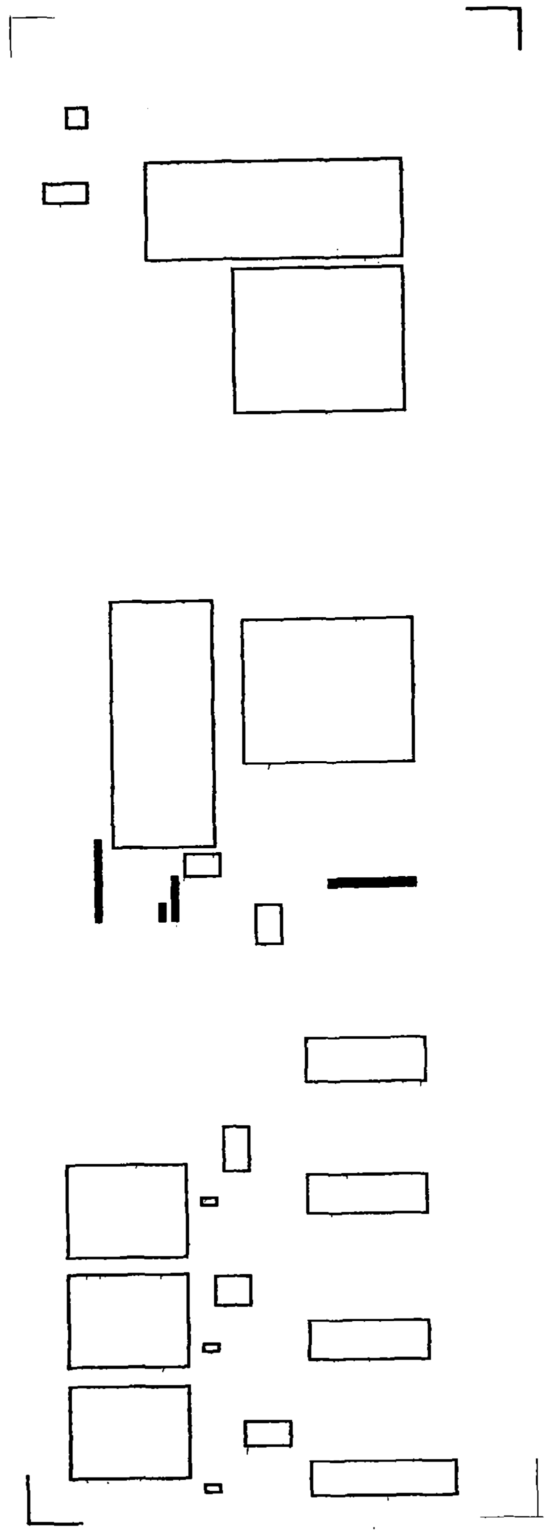


Figure A-5. Dielectric Mask

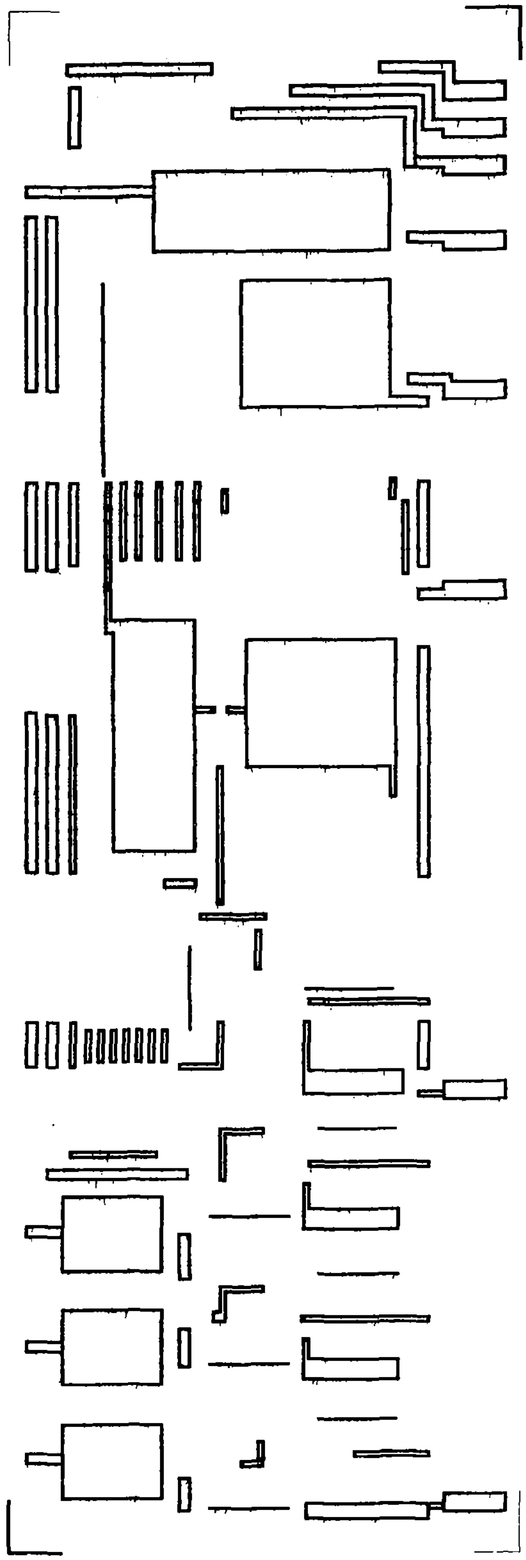


Figure A-6. Second Conductor Mask

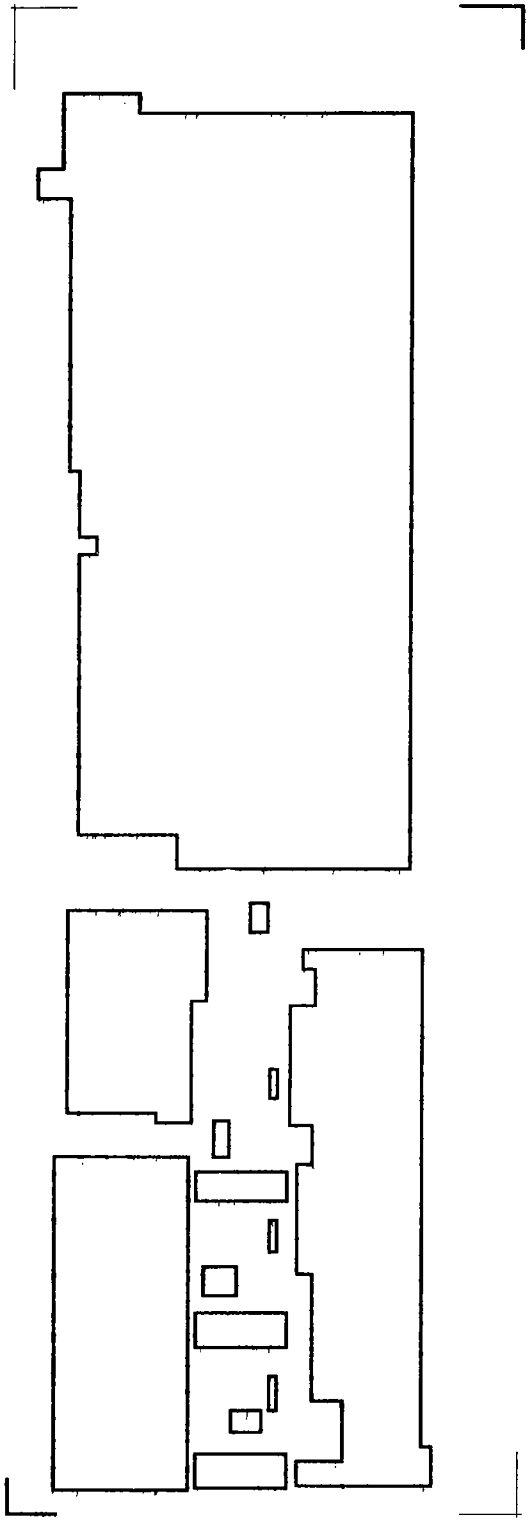


Figure A-7. Protective Coating Mask

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